On Particle Mass Changes and GR: Space-time Topology Causes LHC Leakage

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Abstract. It is argued that a change in particle rest mass reconnects space-time. The LHC can probe this topological effect through the particle leakage ($\geq 20\%$) that it experiences in particle mass changing interactions.

Mach's principle formed one of the great motivations for Einstein's general theory of relativity (GR); the inertia of matter locally is determined by the mass distribution of the universe globally. The Einstein equation, using the equality of inertial and gravitational mass, expresses this through the interplay between space-time curvature and energy-momentum. In particle physics, the Higgs symmetry breaking[1] mechanism is believed to introduce the rest masses of elementary particles below the, spatially constant, electroweak energy scale, $E_H = 246$ GeV. If particles enter a measuring apparatus with an energy well above E_H then the subsequent interactions can restore the electroweak symmetry locally and temporarily, and observers should find different rest masses.

However, in order to quantify particle mass changes one needs to measure masses in a region that is not affected by such changes. I.e., any quantification of particle mass change can only be defined sufficiently far away from the interaction region in which those changes are in effect. Afterall, if the weighing apparatus is part of the region then no unambiguous particle mass change can be assessed. All processes, be they gravitational or non-gravitational, depend on particle masses, so some form of remote measurement appears to be necessary for mass changing processes, unless one is content with an a priori given absolute mass scale. Therefore, it is appealing to elevate this mass measurement requirement to a strict physical principle that renders any particle mass changing process intrinsically non-local; forcing particles that express rest mass changes to be present outside of the rest mass changing region. That is, any detectable change in particle masses, when new particles are created under electroweak symmetry restoration, must be linked to an observed non-locality in the positions of those particles. This immediately implies that the global mass distribution of the universe is altered, in some way, during particle mass changing events.

The magnitude of this non-locality can be quantified through a dimensional argument. For isotropic space-time, all observers living now can receive information on a portion of the universe with a size that is equal to the particle horizon, R. With

Planck's constant h and speed of light c, the ratio $D \equiv RE_H/hc \sim 10^{44}$ then constitutes the maximum extent over which any observer can speak of the locations of particles as well as of rest masses. Afterall, measurements on scales smaller than $l = hc/E_H$ cause restoration of the electroweak symmetry. Since all particle mass changing events are an undeniable consequence of the global mass distribution of the universe, the value of D cannot be exceeded during particle mass changing events. A duration $t = l/c$, in an inertial frame, for which the electroweak symmetry is restored by an event, should thus allow observers to detect particle mass changes up to a scale R. Similarly, $RE_H/hc \sim L/cT$ generally holds, in the same inertial frame, for the scale L up to which particle mass changes are observable for a duration T. Even for T much smaller than t, the value of L is truly macroscopic and one is confronted with a problem. How can the non-local effects of particle mass changes, be they in the form of quantum fluctuations or macroscopic experiments, be carried across such distances?

Because E_H is very much smaller than the Planck energy, wormholes are not likely to be useful in this[2], while superluminal motion is not allowed either under Lorentz covariance. This suggests topological identifications, which are unrestricted in GR, as the only large scale option[3,4]. The relative size scale argument above implies that topological identifications are to be made through time, e.g., a three-torus embedded in four-space.

Consider then particle rest mass changes in an accelerator experiment. Within a four-dimensional spherical region U, centered on the experiment and of linear size L, the probability density to create a topological identification through time between the center of U and another spatial point scales like $1/r^3$, for an observer with a measuring apparatus residing at a distance r from the center of U and on its spatial boundary. The probability to find a particle with a changed rest mass outside of a radius r, with $cT < r \leq L$, is then $p \sim log(L/r)/log(L/cT) = log(DcT/r)/log(D)$, only weakly dependent on computational details that affect L.

The LHC[5] that becomes operational soon, reaches energies in excess of 10 TeV, much larger than E_H. Thus, the LHC can induce particle mass changes and probe space-time reconnection effects through the particle leakage that it experiences. I.e., $L \sim 10^6$ km, even if T is as small as the Planck time, with a probability $p \sim 20\%$ to encounter particles with changed rest masses beyond $r \sim 10$ m from an experimental region. If leakage is confirmed, then a topological description of space-time[6,7] and particle rest mass seems appropriate, and one that deals with quantum fields[2,8].

References

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